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(54) **Peristaltic pump and pumphead therefor**

(57) A pumphead for use with a pumping tube 3 comprises axially oriented rollers 5, a central rotatable shaft 6, and platen, or "track", 10, The rollers are rotated through planetary gearing 8, 9, which may be helical, by the shaft 6; and the track is spring-loaded towards the rollers and shaft by e.g. a spring 13, and may be pivoted at 12. These provisions extend the tube life. The pump comprises at least one pumphead and means for driving the shaft(s) 6 e.g. an electric, or pheumatic, motor.

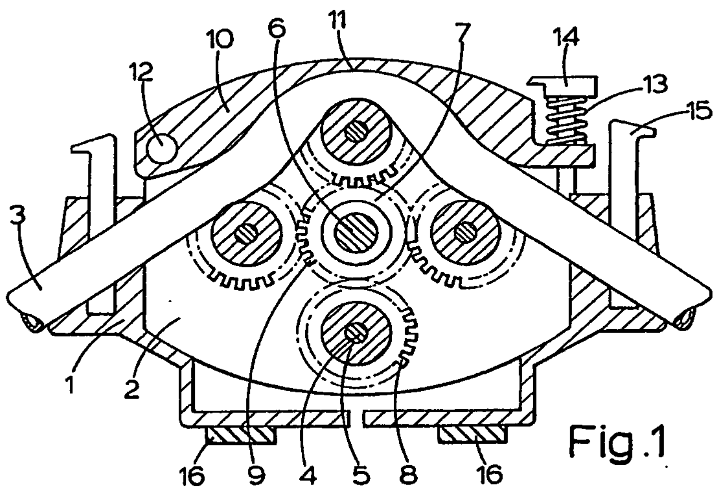

Fig.1

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The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

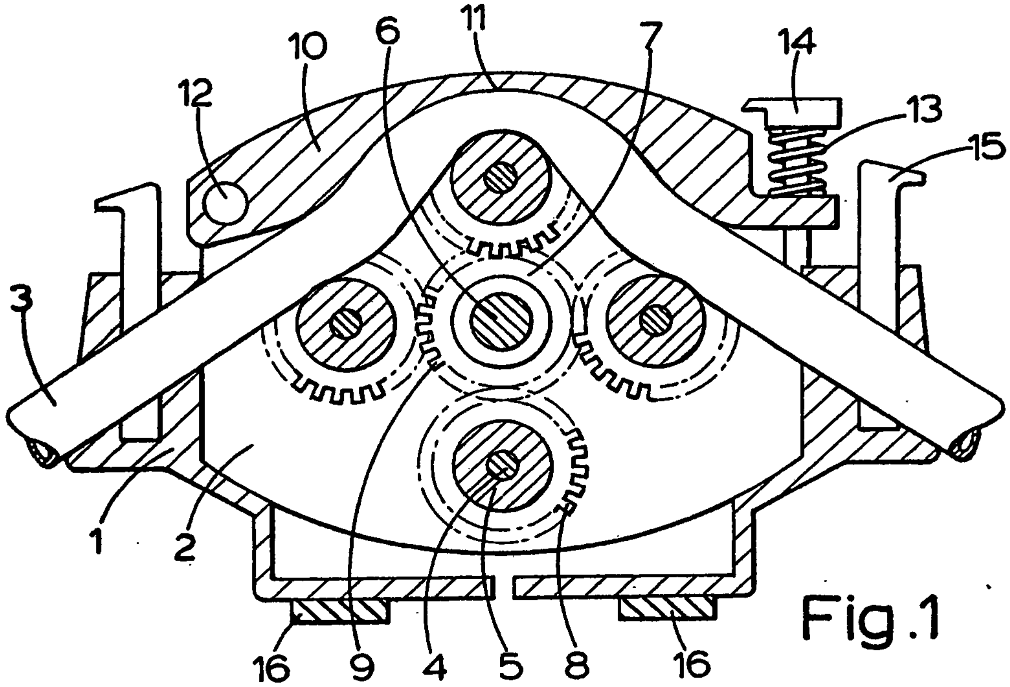

Fig.1

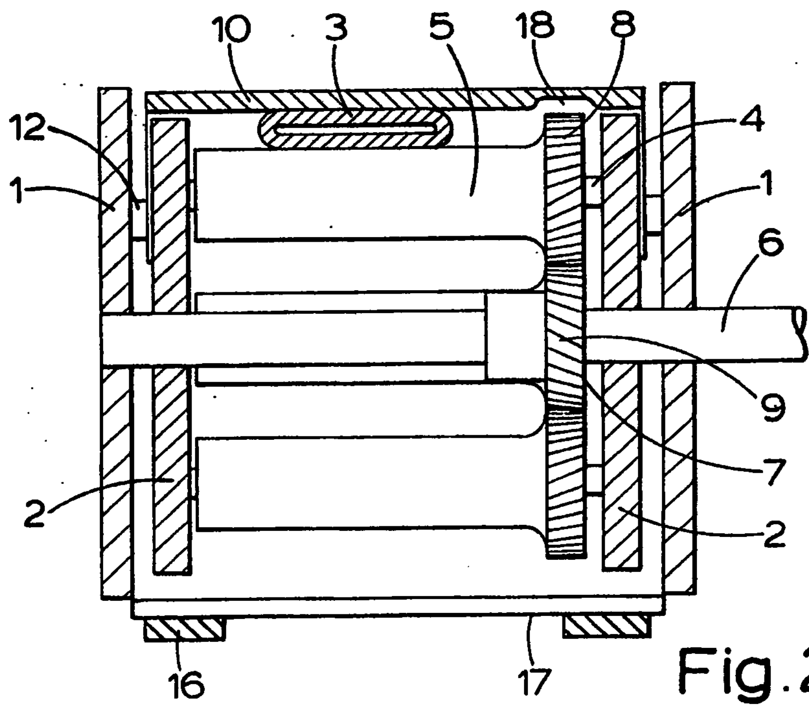

Fig.2

SPECIFICATION

Peristaltic pump and pumphead therefor

This invention relates to a peristaltic pump and more particularly to a pumphead for use in such a pump. The pumphead is of the type in which axially-mounted rollers are supported around a central rotatable shaft and in which a track is provided. The rollers and the track are adapted to receive a resilient flexible tube in such a manner that upon rotation of the rotatable shaft the rollers compress the tube against that track and so exert a pumping action on a fluid present within the tube.

Peristaltic pumps in which the pumphead comprises typically three or four freely rotatable, axially-mounted rollers supported around a central rotatable shaft and an arcuate track upon which is supported a resilient flexible tube have been used in the chemical industry for many years. Such pumps are generally required to pump either large quantities of fluid or fluids which contain particulate matter or fluids which may be very viscous. In handling such fluids, stress and strain are caused to the tube and this has a tendency to shorten the life of the tube. Also if the rollers compressing the tube are freely rotatable about their axes then during the pumping operation there is considerable friction between the rollers and the tube which may cause the tube to get hot. This further tends to shorten the life of the tube and may in turn require the cessation of pumping to allow the system to cool or may require an external cooling means.

A further disadvantage of some previously used pumps is that the distance between the surface of the rollers and the surface of the track was fixed or might be adjusted only incrementally. This severely limited the size of tube which might be used with any one type of pump.

The peristaltic pumphead of the present invention seeks to mitigate these disadvantages by driving the rollers over the tube by means of a planetary gearing system driven by the rotatable shaft. Furthermore by selecting a suitable gear ratio between a toothed gear wheel on the central shaft and a toothed portion of the roller, the friction between the rollers and the tube is greatly reduced. This gives a more accurate, steady flow rate, is less wearing on the tube even when pumping potentially abrasive or viscous fluids and reduces the generation of heat in the tubing. The effective life of a tube may be increased by up to or in excess of 10 times. By additionally making the track spring loaded various sizes of tube may be used without major adjustments. This also reduces the wearing effect of any imperfections in the walls of the tube.

Peristaltic pumps incorporating pumpheads of the present invention may also be easier and cheaper to manufacture, be lighter and operate more quietly and coolly. The pump will also be cheaper to run as the tube will need replacing less often.

Accordingly the present invention provides a peristaltic pump head adapted to receive a resilient, flexible tube through which a fluid can be pumped by the pumphead, which pumphead comprises a plurality of axially-mounted rollers which are supported for rotation about a central rotatable shaft and in which a track is provided, the rollers and the track being adapted to receive a flexible tube in a manner in which a fluid is caused to be pumped through the tube upon rotation of the central rotatable shaft characterised in that the rollers are rotated by planetary gearing by the central rotatable shaft and that the track is spring loaded to bias the track in the direction of the central rotatable shaft.

Suitably the pumphead will employ at least three axially mounted rollers and preferably will contain four, five or six rollers. Aptly the rollers are supported between two support members which are in turn supported for rotation on the central shaft. Suitably the rollers will have an internal bearing to allow rotation about the mounting axle which is held between the support members or alternatively the bearing may be omitted if the rollers are made from a self-lubricating polymer such as nylon which contains molybdenum disulphide. Preferably the rollers are formed from an acetal resin such as Delrin (Registered Trade Mark of DuPont de Nemours Ltd).

Around the end of each roller is a toothed portion which is adapted to enmesh with a toothed gear wheel which is mounted on the central shaft. The rotation of the central shaft will, via the enmeshing portion, cause rotation of the rollers. The toothed portions may suitably have the teeth aligned with the axis of the central shaft. Preferably, however, the teeth are cut at an angle to provide helical gearing at the end of each roller. The teeth on the gear wheel on the central shaft are therefore also cut in a helical fashion. The use of helical gears has been found to reduce or eliminate the noise of the pump during operation.

It has been found that the angle at which the helical teeth are cut with respect to the axis of the central shaft depends upon the balance of eliminating noise which requires an increasing angle and avoiding axial thrust in the gearing which also increases as the angle increases. It has been found that the optimum angle which gives maximum efficiency in use of the pumphead against acceptable noise level is between 25° and 35° and most preferably 30°.

The central shaft carries a toothed gear wheel mounted in a position between the two support members mounted on the central shaft so that it enmeshes with the toothed portions of the rollers. Suitably the gear wheel is made from metal and preferably is made from steel. The size of the toothed portions of the rollers are substantially the same as that of the toothed gear wheel. For maximum efficiency and to maximise tube life the size of the toothed gear wheel and the size of the toothed portions of the rollers are the same, so that each revolution of the shaft causes one revolution of each roller. This means that there is substantially no relative movement between the

rollers and the tube at their point of contact so that the lack of friction between the two prolongs the active life of the tube.

The track against which the tube is compressed by the rollers is spring loaded to bias the track in the direction of the central shaft. The spring pressure can be pre-set to maximise tube life and to vary the delivery pressure capability of the pump. The spring loading may be provided in a conventional manner by compressing a spring against the external surface of the track, for example by placing the spring around a screw threaded bolt and compressing the spring by screwing a nut along the bolt. The spring loading also allows tubes of various sizes to be used. The presence of the springs also provides some resilience to the track which will prolong the life of the tube if imperfections are present in the tube in the repeatedly compressed sections.

Suitably the track may be spring loaded at either or both ends. Preferably the track is hinged at the inlet side and is spring loaded at the delivery side. The track being hinged allows easy access to the inside of the pumphead, as for example when inserting the tube before use. With most peristaltic pumps the tube has a greater tendency to wear at the delivery side because the tube slips back as the pressure is released from the tube. With the incorporation of spring loading at the delivery side, this slip back and thus tube wear are reduced.

Preferably the track is spring loaded by means of a metal spring. Suitably the spring may be placed on a hinged latch, the bolt of which is screw threaded. The spring may be compressed between a nut, capable of being moved along the bolt by means of the screw thread, and the external surface of the track. The compressive force and the distance between the track surface and the surface of the rollers being determined by the position of the nut. Also, but not preferably, the track may be spring loaded using an alternative compressing means having equivalent action to the spring. Such means include a compressible rubber or plastic sleeve, which may be used in cooperation with a hinged latch.

If there is insuffient spring pressure on a pump delivering at a high pressure then pumping is insufficient. If there is excessive pressure applied on low fluid pressure applications there would be undue tube wear. It is possible with this pump head to indicate in relation to the position of the screw-threaded nut compressing the spring on the bolt of the hinged latch the required pressure for any application.

The hinge which hinges the track to the end plate may be simple cup hinges whereby the track may be simply lifted away from the pumphead to allow easy access to the inside of the pumphead. Alternatively the hinge may be in the form of a single, readily-removable pivot pin which passes through the outer-end plate, track and inner-end plate. The hinge pin passes through concentric bushes set in the end plates. By concentric it is meant that the hole through which the pin is inserted is in the centre of the bush. An additional advantage may be given to the pumpheads of the present invention if the bushes are eccentric, that is the hole for the pin is not in the centre of the bush. By releasing the bushes from the end plates, rotating them through 180° and re-securing, the attitude of the track with respect to the rollers may be changed. This has the effect that tubing of different wall thickness or sizes can be used without changing the track. For example tube sizes of 4.8 mm wall thickness and 3.2 mm wall thickness could be used with the same track using eccentric hinges.

The operative length of the track, that is that portion of the track over which the tube is occluded, is governed by the number of rollers present in the pumphead. The operative part of the track is in the form of an arc of a circle. If there are four rollers present then the operative length of track is an arc which subtends 90°C at the centre of the circle, that is the angle given by 360/no. of rollers. Thus if only three rollers are present this angle is 120° which unless the tubing is of a small diameter tends to make the pumphead difficult to operate effectively.

Suitably the whole of the track length may have a profile which minimises pulsation in the delivery of the fluid which has been pumped. Suitable profiles have been described in our co-pending British Application No. 2076078A which is incorporated herein by cross reference.

Suitably the central rotatable shaft may be driven by a permanent magnet motor which is capable of being adjusted to run at a variety of speeds from 0 to 2000 rpm. Alternatively, induction motors, geared induction motors, pneumatic and other drives can be used. Suitably the central rotatable shaft is mounted between two end plates. The end plates each contain a bearing with which the shaft rotates. The support members and rollers are mounted on a central shaft between two end plates. In a particularly preferred embodiment of the invention the arcuate track is hinged at one end between the end plates and when fastened in position by the hinged latch encloses the support member within the end plates and track.

In a further aspect the present invention comprises a peristaltic pumphead adapted to receive a resilient, flexible tube through which a fluid can be pumped by the pumphead, which pumphead is of the type in which axially mounted rollers are supported for rotation about a central shaft and in which a track is provided, the rollers and the track being adapted to receive a flexible tube in a manner in which a fluid is caused to be pumped through a tube upon rotation of the rotatable shaft characterised in that the rollers are rotated by helical planetary gearing driven by the central shaft.

The helical gearing is present around one end of each roller as hereinbefore described and each enmeshes with a complementary gear wheel mounted on the central shaft.

In a further embodiment the present invention comprises a pump comprising a peristaltic

pumphead as hereinbefore described and a drive means adapted to rotate the central shaft.

In a further aspect, the invention comprises a pump in which are present at least two pumpheads, that is two pumpheads are driven by the same motor hence giving delivery of two or more liquids at the same time. The drive onto the second and subsequent pumpheads being achieved by having a tongue on the drive shaft of the second pumphead which engages with a slot in the drive shaft of the first head.

A safety feature may be built into the design of the pumphead. A particularly important feature is one which will stop the pump if the track is raised during operation. This will prevent objects or fingers becoming entangled with the moving rollers. The safety feature may be a microswitch or preferably a small magnet which is included in the track opposite a reed switch. When the track is in position the reed switch is switched to allow the pump to operate. If the track is moved, for example by opening, the magnet moves away from the reed switch and it switches off, preventing any further operation of the pump.

A preferred embodiment of the present invention will be further described with reference to the accompanying drawings, in which:

Figure 1 shows a cross-section through the pumphead with a resilient flexible tube and Figure 2 shows a cross-section taken at right angles to that shown in Figure 1.

Figure 1 shows a cross-section through the pumphead which particularly illustrates the arrangement and relationship of the four rollers and the toothed gear wheel on the central shaft. In the figure, one of the end plates (1) which supports the central shaft is shown. Support member (2) is one of the pair which support the rollers (5) on axles (4). Central shaft (6) passes through both end plate (1) and support member (2), the shaft being held in bearings in the end plates. The central shaft (6) carries a toothed gear wheel (7) which is positioned between two support members. The toothed part (9) of the gear wheel (7) is aranged to enmesh with the toothed portion of the rollers (8). In this embodiment each rotation of the toothed gear wheel (7) provides one rotation of each roller (5). Typically each toothed portion has 35 helically cut teeth, the direction being 30° to the axis of the roller. The arcuate track (10) is hinged to the end plate (1) by hinge (12). The operative part of the track (11) is that part of the track over which the tube (3) is totally occluded by each roller (5) as it passes over the tube. The shaft is preferably driven in a clockwise direction so that the spring loading is present at the delivery side of the pumphead. The spring loading comprises a hinged latch (14) which carries a spring (13) which may be compressed between the head of the latch and the end of the track. The tube (3) is held in the pumphead by means of v-shaped latches (15) mounted in base casting (17). The pumphead stands on a resilient hard rubber base (16).

Figure 2 shows a cross-section through the pumphead which is at right angles to that shown in Figure 1. The end plates (1) are shown connected to a base casting (17) which stands on the resilient base (16). The central shaft (6) passes through the end plates (1) to be connected to a drive means (not shown). The support members (2) are mounted for rotation on the central shaft (6). The toothed gear wheel (7) is positioned on the central shaft (6) between the two support members (2) so that the helical portion (9) enmeshes with the helical portion (8) of the rollers (5). The resilient flexible tube (3) is compressed between the rollers (5) and arcuate track (10). The track (10) is hinged to the end plates (1) by means of hinges (12). The hinges may be simple cup hinges whereby the track may be easily lifted away from the pumphead. The track may have a groove (18) to accommodate the toothed portion of the rollers.

CLAIMS

1. A peristaltic pumphead adapted to receive a resilient, flexible tube through which a fluid can be pumped by the pumphead, which pumphead comprises a plurality of axially mounted rollers which are supported for rotation about a central rotatable shaft and in which a track is provided, the rollers and track being adapted to receive a flexible tube in a manner in which fluid is caused to be pumped through the tube upon rotation of the central rotatable shaft characterised in that the rollers are rotated by planetary gearing by the central rotatable shaft and that the track is spring loaded to bias the track in the direction of the central shaft.

2. A peristaltic pumphead as claimed in claim 1 in which the number of axially mounted rollers employed is four.

3. A peristaltic pumphead as claimed in claim 1 in which the number of axially mounted rollers employed is six.

4. A peristaltic pumphead as claimed in any of claims 1 to 3 in which the planetary gearing is in the form of toothed gear wheels in which the teeth are cut at an angle of between 25 and 35° to the axis of the central rotatable shaft to provide a helical gearing.

5. A peristaltic pumphead as claimed in any of claims 1 to 3 in which the planetary gearing is in the form of toothed gear wheels in which the teeth are cut in a direction parallel to the axis of the central rotatable shaft.

6. A peristaltic pumphead as claimed in any of claims 1 to 5 in which the gear wheels of the planetary gearing are the same size.

7. A peristaltic pumphead as claimed in any of claims 1 to 5 in which the spring loading is provided by compressing a spring against the external surface of the track.

8. A peristaltic pumphead as claimed in any of claims 1 to 7 in which the track is spring loaded at the delivery side of the pumphead and hinged at the inlet side of the pumphead.

9. A peristaltic pump which comprises a pumphead as claimed in any of claims 1 to 7 and a

drive means adapted to rotate the central shaft.

10. A peristaltic pump as claimed in claim 9 in which the drive means is a permanent magnet motor.

11. A peristaltic pump as claimed in either of claims 9 or 10 in which more than one pumphead is driven by the drive means.

12. A peristaltic pumphead as described herein with respect to the drawings.

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